CHAPTER X: INTRODUCTION TO BRAIN IMAGING

So let me take another cut at why we're here today, what we're here to discuss. We'd ultimately like to use the tools of modern neuroscience and in particular, the one I'm most familiar with, of course, and that's brain imaging, to study the underlying physiology, biology of acupuncture to try to develop a comprehensive understanding of potential mechanisms and then to use those mechanisms and that understanding to help us design better trials that are suited to understanding the potential role of acupuncture in the treatment of a wide range of conditions.

So, why neuroimaging? How is it that we're approaching that? Let me take a little bit of a step back. Because I'm sure many of you are familiar with this, but perhaps others maybe less, why it is that we're using neuroimaging as a particular way, not the only way, but a particularly powerful way to try to understand how the brain may be working in the face of an acupuncture treatment.

By way of analogy, we can think of digital computer. And of course, when we try to understand how a digital computer works in the same way we might try to understand how the brain works, it's important to realize, of course, that there are many different levels that we can approach the question.

We can approach it literally from the quantum mechanical level of how semiconductors work, through or how we build integrated circuits, how we wire those circuits together, and ultimately, how we get those circuits communicating both within themselves, within a single computer, for example, and in fact, how we even get those computers to talk to each other.

Now like the brain, the computer has this large hierarchical system. But I would maintain that if you really want to understand the details, say, of the quantum mechanics of semiconductors, you really don't need to know very much about what Bill Gates and his colleagues are doing on the software side.

And vice versa, it's fair to say that as brilliant as Bill is on the software network side, he probably can't describe the Hamiltonian of the spin hole interactions in any great detail and there's probably no need to.

So this is one of the reasons why I would maintain that the analogy with the human brain, while strong and compelling at one level, may somewhat break down and obviously leading to why neuroimaging. Because like the computer, the brain also has its multiple levels, from the molecular level to what's happening at the synapse, to the physiology of single cells, multiple cells working together in columns, systems of integrated neurons, all the way up, of course, to the sociology, to the interaction between these computer units.

And yet I'd maintain if, for example, you want to really understand, say, a sociological problem, say a substance abuse, drug addiction, there's really no fundamental way to make progress in that at a fully comprehensive level if we don't understand the underlying molecular biology of what causes addiction in the brain and what sub serves the reward circuitry involved in this abnormal reinforcing function, that it's just a requirement to understand the brain to integrate across multiple levels. And indeed, it's in that challenge of moving across scales that imaging I think has its greatest role.

In animal systems, to some extent in humans, we of course can use invasive measures to measure everything from the molecular biology up to cellular events. Non-invasively, we can do systems level cognitive behavioral studies, interact with the brain.

But we have a gap to bridge and it's that gap that imaging is so potentially useful at doing, both for its ability to image anatomy at scales that range from the cellular, all the way up to systems level, in vivo, and even more important because of its ability to provide functional measures, measures of biochemistry, measures of electrical activity, measures of circuit function at multiple scales, that imaging has a way to potentially bridge the cellular with the systems level and allow us to make these comprehensive connections across levels that I think we're going to need to understand any fundamental cognitive function, of which acupuncture effects may certainly be one.

Now functional neuroimaging of course itself is not a single domain. There are many different technologies that have been developed over the last 30 years now which have had a profound effect on how we can study the brain in vivo, in humans, in our patients, as well as in basic studies of neurobiology.

They include things like MEG and EEG, things that allow to measure rapid transient electrical dynamics in the brain, transcutaneal magnetic stimulation, a way to stimulate focal parts of the brain in vivo and then to correlate those measures with the recordings that you can make in a more invasive setting, say during the time of surgery.

Optical imaging, another domain that I won't talk about, but which is becoming increasingly important because of its ability to image populations that are very hard to image with other technologies like magnetic resonance, in particular, small children or very sick patients in a neurointensive care unit.

But the technologies that I'll talk about today are basically **magnetic resonance imaging, functional magnetic resonance imaging and positron emission tomography**. And they are connected through the wonderful high resolution anatomy that magnetic resonance can provide. Essentially, it's the linchpin that connects all of these different modalities and provides a common anatomical framework for us to understand all the different kinds of function that we can learn using these tools.